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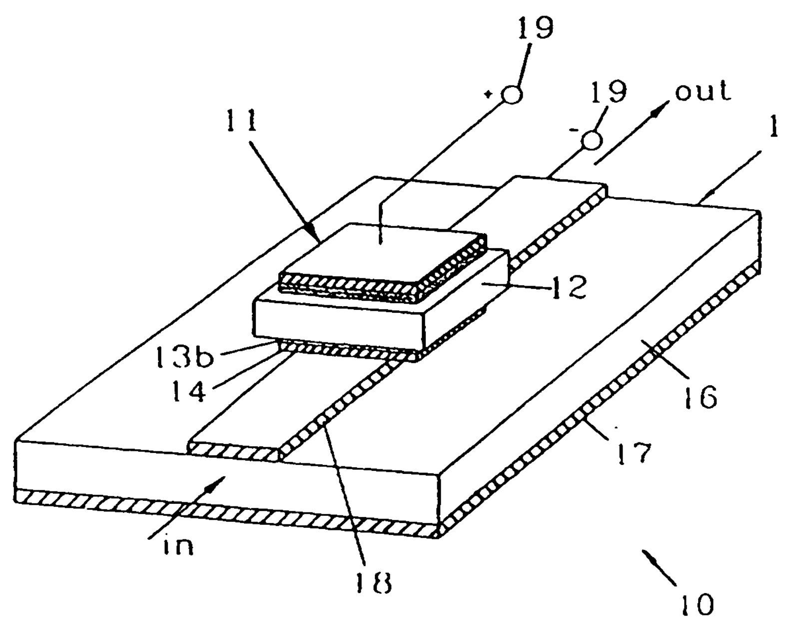

(57) Abstract

The present invention relates to a superconducting notch or band reject filter arrangement (10) which comprises a superconducting dielectric resonator (11) and a waveguide arrangement (15) comprising a microstrip line to which the resonator is connected. The resonator (11) is a parallel-plate resonator with a chip of a non-linear dielectric material (12) on which superconductors (13a, 13b) are arranged and the waveguide arrangement comprises contact means or a coupling means (18), the resonator (11) being connected to said contact means (18) of the waveguide arrangement in such a way that electric contact is provided and the filter arrangement is frequency tuneable. Through said arrangement the insertion losses are low.

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Title:
ARRANGEMENT AND METHOD RELATING TO FILTERING OF SIGNALS.

TECHNICAL FIELD

The present invention relates to superconducting filter arrangements, particularly notch filters or band reject filters which comprise a superconducting dielectric resonator and a waveguide arrangement such as e.g. a microstrip line.

One of the applications of notch filters or band reject filters is within communications systems. A particular application of such relates to multichannel microwave communications systems which operate in high frequency bands in which the size of the components is highly important.

The invention also relates to a method for filtering signals incoming to a receiving arrangement in a multichannel communication system.

STATE OF THE ART

Since for example frequency multiplexers, band reject filters etc. are among the key elements in multichannel communication systems, efforts have been made to find a way to reduce the insertion losses and the size of these components. For multichannel microwave communication systems operating in the 1-3 GHz frequency band insertion losses are high for presently used devices.

It is known to use YIG (Yttrium Iron Garnet) notch filters in the front end of microwave receivers to blank out intermittent interfering signals. However, the insertion losses are high. Moreover the size of such filters is large. In "High-Temperature

Superconducting Microwave Devices", by Shen, Artech House, 1994 the use of high temperature superconductors is discussed for providing new possibilities to reduce the size and to improve the performance of microwave components, for example filters.

European Patent Application EP-A-0 567 407 discloses superconducting notch filters with a fixed frequency wherein half wavelength, high temperature superconducting microstrip resonators are parallel coupled to the main high temperature superconducting microstrip line. The substrates of the resonators have dielectric constants of about 10-25 at frequencies between 1-3 GHz. The length of the filters is then about 2-6 cm; the filters are thus very large and they are also expensive.

In some communication systems tuneable (switchable) notch filters are required instead of fixed frequency notch filters e.g. in order to increase the flexibility of the system. US-A-4,834,498 shows a simple dielectric resonator. The resonator is passive and it is not itself tunable. To provide tunability additional tuning means are required such as a diod or similar. In other words, a separate biasing circuit is required. This considerably adds to the size of the arrangement. Furthermore, the device as such gets complex and the performance is not sufficiently high. In WO 93/00720 a superconducting notch filter with a microstrip resonator which is not tunable itself is illustrated. In this case optical means are used to provide tuning, which use semiconductor crystals in superconducting microstrip ring resonators coupled to the main superconducting microstrip. However, the dimensions of these arrangements are large and moreover the frequency tuning range is much too small. Both of the above mentioned documents show passive resonators and devices requiring a special bias network and additional tuning means which are coupled to a main microstrip line in the same way. The resonators cannot be in mechanical or

electrical contact with the main microstrip line. If there is no coupling, there is no filter.

To summarize, both these devices need additional tuning means with a separate biasing circuit. That makes the designs large as well as complex. Furthermore, the electrical performance of the filter is negatively affected therethrough and it is also as such not as high as would be desired. E.g. for frequencies of about 1-3 GHz the devices as disclosed in these documents would be much too large and they cannot for example be used for telecommunication purposes.

It has also been found that microwave devices can be made smaller if high dielectric constant non-linear dielectric materials such as for example Strontium Titanate (STO) are plated with superconductors such as e.g. Y-Ba-Cu-O (YBCO). WO 94/13028 discloses the use of thin single crystalline dielectric films in combination with high temperature superconductors which as such however produce too high microwave losses and moreover such devices cannot be made small enough.

SUMMARY OF THE INVENTION

What is needed is therefore a superconducting notch filter arrangement which has low insertion losses, small dimensions and which is tuneable. Particularly an arrangement is needed which is tuneable within a large frequency range. Moreover an arrangement is needed which is cheap and easy to fabricate. Still further an arrangement is needed which has a high performance as stated above has low losses, particularly low microwave losses (in the case of microwaves); it can also be used for millimeter-waves.

A method for filtering signals incoming to for example receiving arrangements in a multichannel microwave communication system operating at high frequencies is needed throuh which intermittent

and interfering signals can be blanked out in an efficiant and reliable manner.

Therefore a superconducting notch filter arrangement is provided which comprises a resonator arranged on a microstrip line wherein the resonator is a parallel-plate resonator with a chip of a non-linear dielectric material on which superconductors are arranged. The resonator is connected to connecting means of a microstrip line or a strip of the microstrip line in such a way that an ohmic contact is provided. Through the use of a parallel-plate resonator it can be arranged on top of a microstrip line, coupling is provided and the dimensions can be reduced. No special bias network is needed and no additional tuning means. The arrangement is particularly electrically tuneable, still more particularly through the application of a DC biasing voltage to the non-linear dielectricum of which the dielectric constant can be changed. In a particular embodiment a DC voltage is applied to normal conductors which may be arranged on the superconductors arranged on the dielectricum of the resonator. Advantageously contact means, also denoted coupling means, are arranged to provide for dielectrical contact between the resonator and the microstrip line. In an advantageous embodiment the contact means are formed by the central strip of the microstrip line.

In a particular embodiment a resonator comprises a rectangular (or some other shape) chip which is so oriented in relation to the microstrip line that the magnetic field lines of the microstrip line and the resonator substantially coincide in such a way that maximum inductive coupling is produced.

The inductive coupling is particularly controlled or given by the relation between the resonator and microstrip line. Even more particularly the strength of the inductive coupling is given by the

width of the central microstrip. To obtain the desired strength of coupling, the width can thus be given the value which provides the desired coupling.

According to a particular embodiment at least a portion of the lower plate of the parallel-plate resonator and/or the microstrip connecting means, for example the central strip, has/have a first width that is smaller than a second width in order to provide an increased inductive coupling.

According to one embodiment the resonator is a dual mode resonator or even more particularly it is a multimode resonator.

However, dual mode operation is advantageously produced through the introduction of an asymmetry in the resonator. This asymmetry may for example comprise a cut away corner or a protrusion or anything else. According to another embodiment the resonator may be arranged so as to form an angle with the main microstrip line. The angle may for example take the value of approximately 45°.

According to still another embodiment the waveguiding arrangement may comprise a coplanar waveguide. The coupling strength is controlled by or given by the width of the central strip and of the coplanar waveguide slots.

The tuning is advantageously provided (which relates to all embodiments) through the application of a DC biasing voltage which may be applied between the upper plate of the resonator and the coupling means, e.g. the central strip of the microstrip line.

According to an advantageous embodiment the area of the resonator may have a size between approximately 1 mm^2-1 cm^2. However, these

values are merely given for exemplifying reasons, the resonator may also have other proportions, smaller as well as somewhat bigger.

Furthermore a method is given for filtering signals incoming to for example a receiving arrangement of a multichannel communication system or similar. The method comprises the steps of: arranging a filter on the input side of a receiving arrangement, which filter comprises a parallel-plate resonator comprising a non-linear dielectricum on which superconductor plates are arranged, which is arranged on a waveguide, e.g. a microstrip line. The resonator and the waveguide arrangement are connected electrically in series through the use of coupling means. The coupling strength is given by how the resonator and the coupling means are arranged in relation to each other. A DC biasing voltage is applied to the resonator and the coupling means for frequency tuning. The steps are carried out so that intermittent interfering signals can be blanked out.

It is among others an advantage of the invention that it is possible to make notch or band reject filters having dimensions which are considerably smaller and more compact than hitherto known filters. It is also an advantage that the frequency tuning range is large. Furthermore, it is an advantage that the resonator is tunable itself so that no additional or separate tuning means are needed.

It is also an advantage that it is less complex than known arrangements and that it can be made small enough to be used in telecommunications systems.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will in the following be further described in a non-limiting way under reference to the accompanying drawings in which:

FIG 1 illustrates an example of a parallel-plate resonator,

FIG 2 schematically illustrates a first embodiment of a tuneable notch microstrip filter,

FIG 3 is a cross-section of the notch filter of Fig 2,

FIG 4 illustrates an equivalent circuit of the notch filter of Fig 2,

FIG 5 is a diagram illustrating the temperature dependence of the central frequency of a particular notch filter,

FIG 6a schematically illustrates a cross-section of a second embodiment of a notch filter,

FIG 6b is a longitudinal cross-section of the lower plate of the resonator,

FIG 6c is a longitudinal cross-section of the central microstrip line of the filter according to Fig 6a,

FIG 7 illustrates an embodiment of a two-pole notch filter,

FIG 8 is a further embodiment relating to a two-pole notch filter, and

FIG 9 schematically illustrates a coplanar waveguide notch filter.

DETAILED DESCRIPTION OF THE INVENTION

According to the invention a resonator is arranged on a waveguide arrangement. Fig 1 shows a first example of a parallel-plate resonator that can be used. The resonator 11 comprises a dielectrium 12 in the form of a rectangular chip of a non-linear dielectrium on both surfaces of which thin high temperature superconducting HTS films 13a, 13b are arranged. One of the plates of the resonator is connected electrically, DC, (R=O) to the microstrip line. Magnetic coupling means or DC contact means are arranged in such a way that the filter rejection band and central frequency can be electrically controlled. The superconducting films or plates 13a, 13b may advantageously be partly or completely covered by normal conducting films 14,14 for example of Au thus forming ohmic contacts for DC biasing. According to an advantageous embodiment, the dielectric material comprises a non-linear dielectric bulk material since for bulk material the microwave losses are lower and the dielectric constant is higher than for example for thin dielectric films. Through the use of a non-linear dielectric material, electrical controlling is enabled.

The microwave losses of for example Strontium Titanate, hereinafter referred to as STO are close to minimum at the temperature of liquid nitrogen, N_{liq} which is discussed in "Dielectric properties of single crystals of Al_2O_3, $LaAlO_3$, $NdGaO_3$, $SrTiO_3$ and MgO at cryogenic temperatures", by Krupka et al., in IEEE Trans. Microwave Theory Techn., 1994, Vol. 42, pp. 1886-1890. The dielectric constant of STO is about 2000 at the temperature of N_{liq} and it is strongly dependent on temperature and on applied electric DC fields. This is discussed in "1 GHz tuneable resonator on bulk single crystal $SrTiO_3$ plated with $YBa_2Cu_3O_{7-x}$ films", by O. Vendik in Electron. Lett., 1995, Vol. 31, No. 8, pp. 654-656. Since the dielectric constant is extremely high, the wavelength in a microwave transmission line based on STO at the temperature for N_{liq}

in the frequency band 1-3 GHz is about 0.2-0.6 cm. The superconducting transition temperature T_c for HTS such as for example YBCO is well above the temperature of N_{liq} and it is also well known that HTS films grown on STO substrates have a low surface resistance which is discussed in the article cited above by Shen. The resonator may advantageously comprise a non-linear bulk dielectric material 12 e.g. by STO which is covered by HTS films of e.g. YBCO. Of course it is also possible to make the resonators in other ways, but this relates to a particularly advantageous embodiment. If e.g. STO and superconductors are used, the microwave losses are very low. The superconducting films or plates 13a, 13b of the parallel-plate resonator are made slightly smaller than the dielectric chip 12 in order to account for mechanical tolerences and for the provision of an improved ability of controlling the resonant frequency. The thickness of the superconducting plates 13a,13b exeeds the London penetration depth, the penetration depth being defined as the depth at which the field has decreased to 1/e of the value at the surface.

Fig 2 shows a first embodiment of a tuneable notch filter 10 according to the invention. The resonator 11 of Fig 1 is arranged on a waveguiding arrangement 15 in the form of a microstrip line. The resonator 11 is in this embodiment connected to or attached to the central strip 18 of the microstrip line 15 wherein said central strip 18 acts as the contact means or couplings means providing ohmic contact between the lower plate 13b of the parallel-plate resonator 11 and the microstrip line 15. No special bias network, no additional tuning means are required. The microstrip line 15 comprises a substrate e.g. of Al or any other known dielectricum for μw-strips. The ground plane 17 comprises e.g. Cu, Au or anything similar having normal conductivity. However, in a very advantageous embodiment the ground plane 17 and the central strip 18 comprise HTS films. The parallel-plate resonator chip 11 is so

arranged in relation to the microstrip line 15 that the magnetic field lines of the microstrip 18 and the resonator 11 substantially coincide (c.f. Fig 3) thus ensuring a high degree of inductive coupling, or more precisely maximum inductive coupling. The width of the central microstrip 18 determines the coupling strength between the resonator 11 and the microstrip line 15 and thus the coupling strength can be controlled through choosing the appropriate width. The width can in advantageous embodiments be approximately in the range between 0,5-1 mm, but it can also have a smaller or larger width. Thus, in this way a series resonant circuit is introduced into the microstrip line 15 which then acts as a band reject filter, i.e. a notch filter for input microwave signals. Connection means 19, 19 are provided through which a DC biasing voltage can be applied between the microstrip and the upper plate 13a of the parallel-plate resonator 11. In this way electrical tuning is provided and the DC biasing voltage applied to the non-linear dielectric 12 changes the dielectric constant thereof and thus the resonant frequency of the parallel-plate resonator 11.

One of the resonator plates is advantageously in mechanical or electrical contact with the main microstrip line. The main microstrip is advantageously used as a bias terminal for DC-biasing. This is in contrast to e.g. US-A-4,835,498 and WO-A-93/00720, wherein the resonator could not be in contact with a main microstrip line.

According to another embodiment, not further discussed herein, temperature controlled tuning can be applied either in addition to the electrical tuning or as an alternative thereto. Optical or mechanical (e.g. via piezoelectric means) tuning can of course also be used.

Fig 3 is a cross-sectional view of the notch filter 10 as illustrated in Fig 2. It shows how the resonator 11 is arranged on the central microstrip 18 of the microstrip line 15. H denotes the magnetic field lines of the resonator and of the microstrip line. As discussed above, the magnetic field lines substantially coincide thus providing a high degree of coupling between the resonator 11 and the microstrip line 15.

Fig 4 schematically shows an equivalent circuit of the notch filter 10 as illustrated in Figs 2 and 3 above. Z_0 indicates the impedance of the microstrip whereas the dashed line is the circuit representation of the resonator 11. In a particular embodiment, the resonator is a STO resonator plated with YBCO films as discussed above and the dielectricum in this particular embodiment has the dimensions 2.5 x 2.5 x 0.5 mm^3. In this embodiment the waveguide arrangement comprises a 50 Ohm copper microstrip on a 0.5 mm aluminium substrate. Of course this is only one example and other materials can be used, the dimensions can be different etc. Moreover, the parallel-plate resonator does not have to be rectangular but it can also take other forms, square shaped, an oval etc. However, Fig 5 shows a diagram of the temperature dependence of the center frequency of a notch filter having the above mentioned dimensions and no biasing voltage is applied.

In Fig 6a an alternate embodiment of a notch filter 20 is illustrated. A resonator 21, also in this case comprising a non-linear dielectric bulk material 22 plated with thin superconducting films 23a, 23b which in turn are covered by normal conducting layers 24a, 24b for example from Au, is arranged on a microstrip line 25. The microstrip line 25 comprises a substrate for example of Al. On one of its surfaces e.g. a copper microstrip 27 is arranged whereas on the other side of the substrate a central microstrip 28 is arranged. The central microstrip 28 forms the

contact means or the connection means between the resonator 21 and the microstrip line 25. In this embodiment an inductive loading is provided through a second section $23b_2$ of the lower resonator plate 23b having a smaller width then a first section $23b_1$. Also the microstrip 28 is provided with a second section 28b the width of which is smaller than the width of the first section 28a. Figs 6b and 6c are longitudinal views seen from above of the lower plate of the resonator and the microstrip respectively, the arrangement which is illustrated in Fig 6a indicating the portions $23b_2$ and 28b each having a smaller width.

Fig 7 very schematically illustrates a two-pole notch filter. A resonator 31 (e.g. as discussed under reference to previous embodiments) is arranged on a microstrip line 35. One of the corners of the upper superconducting film 33a is cut away; thus producing an asymmetry in the resontor. 32 indicates the dielectricum. Since one of the corners of the upper superconducting film 33a is cut off, it is achieved that the resonator 31 can operate in a dual mode. Thus the width of the rejection band and its skirts can be adapted to the current needs.

Fig 8 shows still a further embodiment of a two-pole notch filter 40. In this case a resonator 41 (c.f. above) is arranged on the microstrip line 45 in such a way that it forms an angle with the microstrip line. In this particular case the parallel-plate resonator 41 forms an angle of 45° with the main microstrip. Since an asymmetry is introduced, the resonator also in this case operates in dual mode. The angle does of course not have to be 45° but it can take a higher as well as a lower value; in principle any angle but 90°.

The invention can in principle also be applied to multimode filters for example operating in three modes. Such an arrangement is illustrated in the at the same time filed Swedish Patent Application "Arrangements and methods relating to multiplexing/switching" having the same applicant, the subject matter of which is incorporated herein by reference.

Fig 9 schematically illustrates yet another embodiment comprising a coplanar waveguide (CPW) tuneable notch filter 50, which also can be dual mode operating. A superconducting parallel-plate resonator 51 is attached to the central strip 58 of a coplanar waveguide (CPW) 55 in order to provide for a higher degree of design flexibility. The coupling strength and the wave impedance of the coplanar waveguide 55 is given by the width of the central strip 58 and the slots 59 of the CPW. In general the width of the central strip can take the values as discussed earlier under reference to Fig. 2 (which also applies to the other embodiments) but in this case the flexibility is even higher. The width is generally chosen depending on the substrate thickness.

The invention is not limited to the shown embodiments but other materials can be used, for example it does not have to be a bulk dielectric material, in some cases also thin dielectric materials can be used. Moreover the form of the resonator can be of different kinds as well as the waveguiding means can take a number of different forms and it does not necessarily have to be a central strip of a microstrip line that forms the coupling means.

CLAIMS

1. Superconducting notch or band reject filter arrangement (10;20;30;40;50;) comprising a superconducting dielectric resonator (11;21;31;41;51) and a waveguide arrangement (15;25;35;45;55) comprising a microstrip line to which the resonator is connected,

characterized in

that the resonator (11;21;31;41;51) is a parallel-plate resonator made of a non-linear dielectric material (12;22;32) on which superconducting plates (13a,13b;23a,23b;33a) are arranged, and in that the waveguide arrangement comprises a microstrip line to which one of the plates of the resonator is connected via contact means or coupling means (18;28;58), the resonator (11;21;31;41;51) being connected to said contact means (18;28;58) of the waveguide arrangement in such a way that electric contact is provided and in that the filter arrangement is frequency tunable.

2. Superconducting filter arrangement (10;20;30;40;50;) according to claim 1,

characterized in

that it is electrically tunable.

3. Superconducting filter arrangement according to claim 2,

characterized in

that a DC biasing voltage via connection means (19,19) is directly or indirectly applied to the plates of the non-linear dielectricum to change the dielectric constant thereof.

4. Superconducting filter arrangement according to claim 3,

characterized in

that normal conductors are arranged on the resonator outer sides, i.e. on the superconductors and in that a DC biasing voltage is applied thereto.

5. Superconducting notch filter according to anyone of the preceding claims,
c h a r a c t e r i z e d i n
that one of the resonator plates is electrically connected or magnetically coupled to the microstrip line.

6. Superconducting filter arrangement according to anyone of the prececing claims,
c h a r a c t e r i z e d i n
that the contact means (18;28;58) comprises a central strip of the microstrip line and in that the resonator is connected to said central strip.

7. Superconducting notch filter arrangement according to anyone of the preceding claims,
c h a r a c t e r i z e d i n
that the parallel-plate resonator (11;21;31;41;51) comprises a substantially rectangular chip.

8. Superconducting notch filter arrangement according to claim 7,
c h a r a c t e r i z e d i n
that the resonator chip is so oriented in relation to the microstrip line that maximum inductive coupling is achieved.

9. Superconducting notch filter arrangement according to claim 8,
c h a r a c t e r i z e d i n
that the resonator chip is so oriented in relation to the microstrip line (15;25) that the magnetic field lines of the microstrip and the resonators substantially coincide.

10. Superconducting notch filter arrangement according to anyone of the preceding claims,
c h a r a c t e r i z e d i n
that the inductive coupling between the resonator and the microstrip line is given by the relation between the resonator and the microstrip and in that it is given by the relation between the physical dimensions thereof.

11. Superconducting notch filter arrangement according to claim 10,
c h a r a c t e r i z e d i n
that the strength of the inductive coupling is given by the width of the contact means, e.g. the central microstrip line (18;28;58).

12. Superconducting notch filter arrangement according to anyone of the preceding claims,
c h a r a c t e r i z e d i n
that in order to increase the inductive coupling between the resonator (21) and microstrip line 25), the lower plate (23b) of the parallel-plate resonator and/or the microstrip connecting means each comprises a second portion ($23b_2$;28b) having a width that is smaller than that of a first width portion ($23b_1$;28a), respectively.

13. Superconducting notch filter arrangement (30;40) according to anyone of the preceding claims,
c h a r a c t e r i z e d i n
that the resonator (31;41) is a dual mode operating resonator and in that the filter arrangement comprises a two-pole filter.

14. Superconducting notch filter arrangement (30;40) according to claim 13,
c h a r a c t e r i z e d i n

that the resonator (31;41) comprises an asymmetry to provide the dual mode operation.

15. Superconducting notch filter arrangement (30) according to claim 14,
c h a r a c t e r i z e d i n
that the asymmetry comprises a cut-away corner of a plate (32a) of the resonator, a protruding portion or similar.

16. Superconducting notch filter arrangement (40) according to claim 13,
c h a r a c t e r i z e d i n
that the resonator (41) is arranged to form an angle with the main microstrip line (45).

17. Superconducting notch filter arrangement according to claim 16,
c h a r a c t e r i z e d i n
that the resonator (41) forms an angle of about 45° with the main microstrip line (45).

18. Superconducting notch filter arrangement (50) according to anyone of claims 1-17,
c h a r a c t e r i z e d i n
that the waveguide arrangement is a coplanar waveguide (55).

19. Superconducting filter arrangement (50) according to claim 18,
c h a r a c t e r i z e d i n
that the coupling strength between the resonator (51) and the coplanar waveguide (55) is given by the width of the central strip (58) and of the slots (59,59) of the coplanar waveguide (55).

20. Superconducting filter arrangement according anyone of the preceding claims,

c h a r a c t e r i z e d i n
that a DC-biasing voltage is applied via connection means (19,19) between the upper plate (14) of the resonator (11) and the coupling means (18), e.g. the central strip.

21. Superconducting band reject or notch filter (10;20;30;40;50) for use e.g. in multichannel communications systems operating in high frequency bands comprising a waveguide arrangement (15;25;35;45;55) and at least one resonator (11;21;31;41;51),
c h a r a c t e r i z e d i n
that the resonator (11;21;31;41;51) is a parallel-plate resonator comprising a non-linear dielectric material (12;22;32) on which superconducting plates are arranged, and in that the waveguide arrangement (15;25;35;45;55) comprises a microstrip line comprising contact means or coupling means (18;28;58), the resonator being so arranged in relation to the waveguide arrangement that a series resonant circuit is provided thus forming the filter, and in that connecting means (19) are provided through which the filter can be frequency tuned.

22. Filter according to claim 21,
c h a r a c t e r i z e d i n
that via the connecting means (19) a DC-biasing voltage is applied.

23. Filter according to claim 21 or 22,
c h a r a c t e r i z e d i n
that the microstrip line comprises a main microstrip line and a central microstrip (18;28;58) forming said coupling means.

24. Filter according to anyone of claims 21-23,
c h a r a c t e r i z e d i n
that the resonator (11;21;31;41;51) comprises a non-linear dielectric bulk material plated with the superconducting plates

(14;24a,24b), advantageously comprising high temperature superconductors.

25. Filter (30;40) according to anyone of claims 21-24, c h a r a c t e r i z e d i n that the resonator (31;41) is a dual mode or a multimode resonator.

26. Filter (31;41) according to anyone of claims 21-25, c h a r a c t e r i z e d i n that it comprises a two-pole notch filter.

27. Filter (10;20;30;40;50) according to anyone of claims 21-26, c h a r a c t e r i z e d i n that the resonator (11;21;31;41;51) comprises a chip having an area of approximately between 1 mm^2 - 1 cm^2 at frequencies of about 0,1-2 GHz.

28. Method for filtering signals incoming e.g. to a receiving arrangement in a multichannel commmunications system comprising the steps of:

- arranging a filter on the input side of the receiving arrangement wherein said filter comprises a parallel-plate resonator made of a non-linear dielectric material on which superconducting plates are arranged and which is arranged on a waveguide arrangement, contact means being provided between said resonator and said waveguide arrangement, e.g. a microstrip line, to provide a coupling in series of the resonator and the microstrip line,

- arranging the resonator and the coupling means so in relation to each other that the needed coupling strength is provided,

- applying a DC-biasing voltage between the resonator and the contact means for frequency tuning,

so that interfering signals are blanked out, i.e. not received in the receiving arrangement.

29. Method according to claim 28, comprising the step of giving the filter the desired coupling strength through giving the contact means or coupling means, e.g. in the form of a central microstrip, such dimensions in relation to the resonator that the desired coupling strength is obtained and in that the resonator comprises a non-linear dielectric bulk material plated with HTS-films.

30. Use of a superconducting notch or band reject filter arrangement according to anyone of claims 1-27 for filtering signals incoming to a receiving arrangement in a multichannel communications system to prevent interfering signals from being received in the receiving arrangement.

FIG. 1

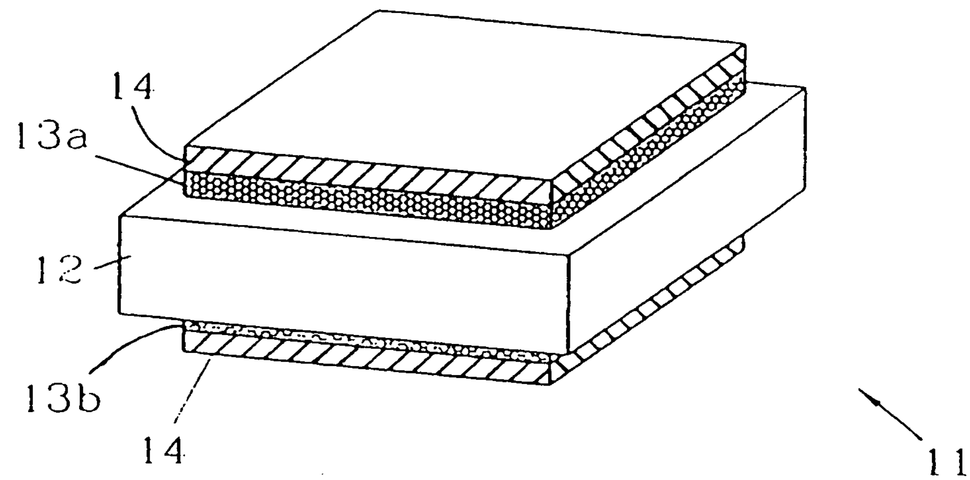


FIG. 2

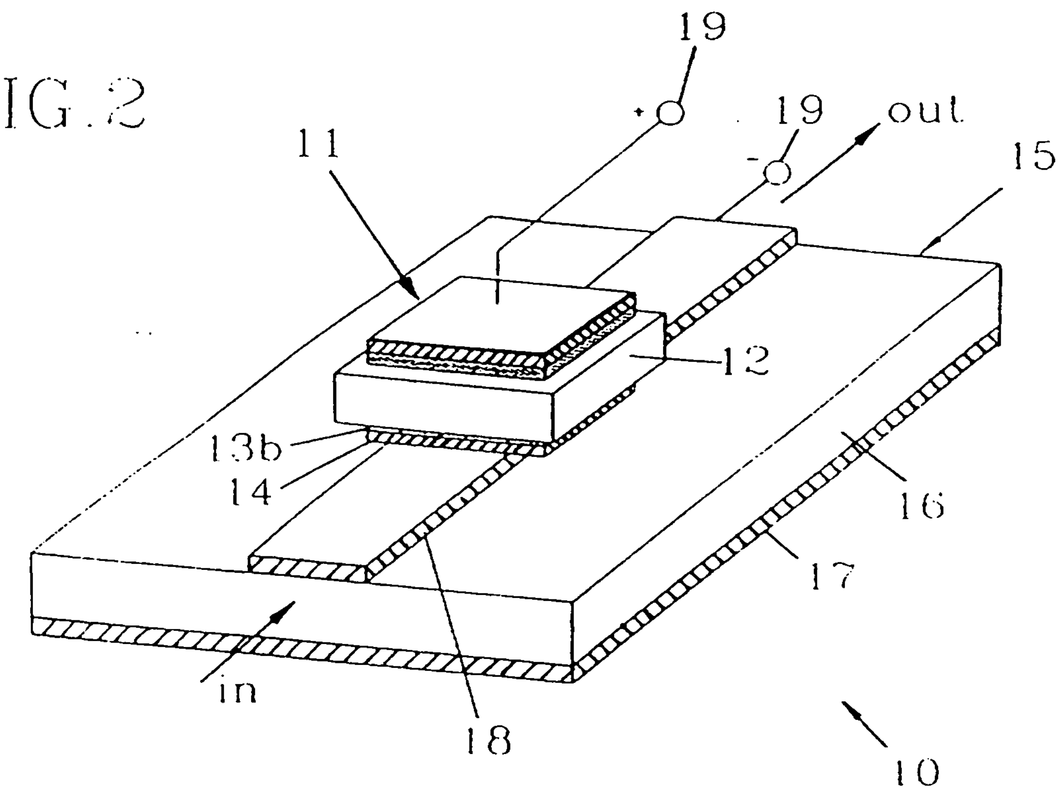


FIG.3

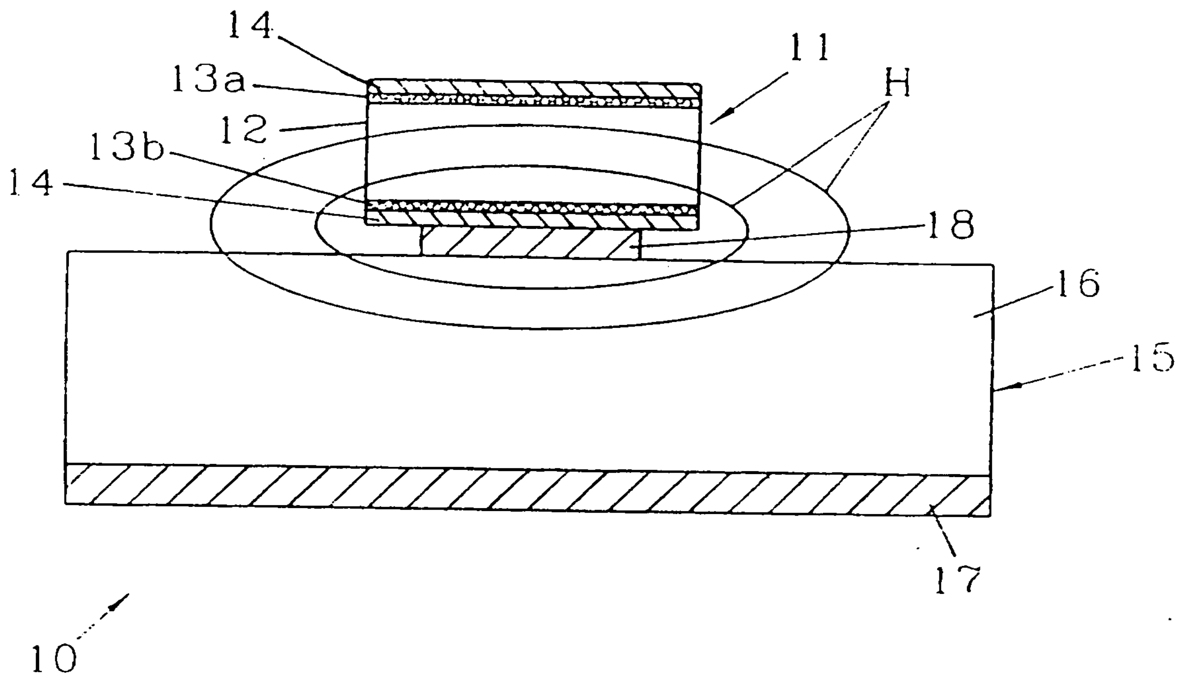


FIG.4

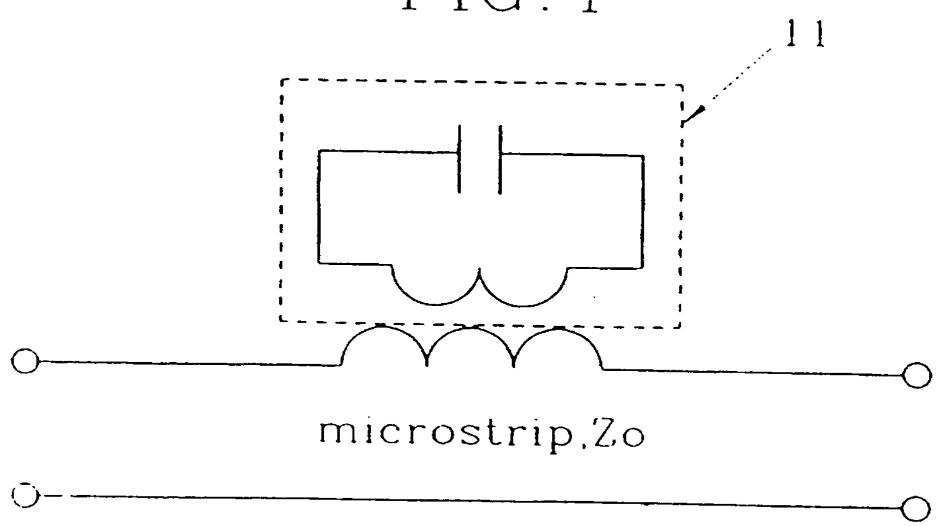


FIG.5

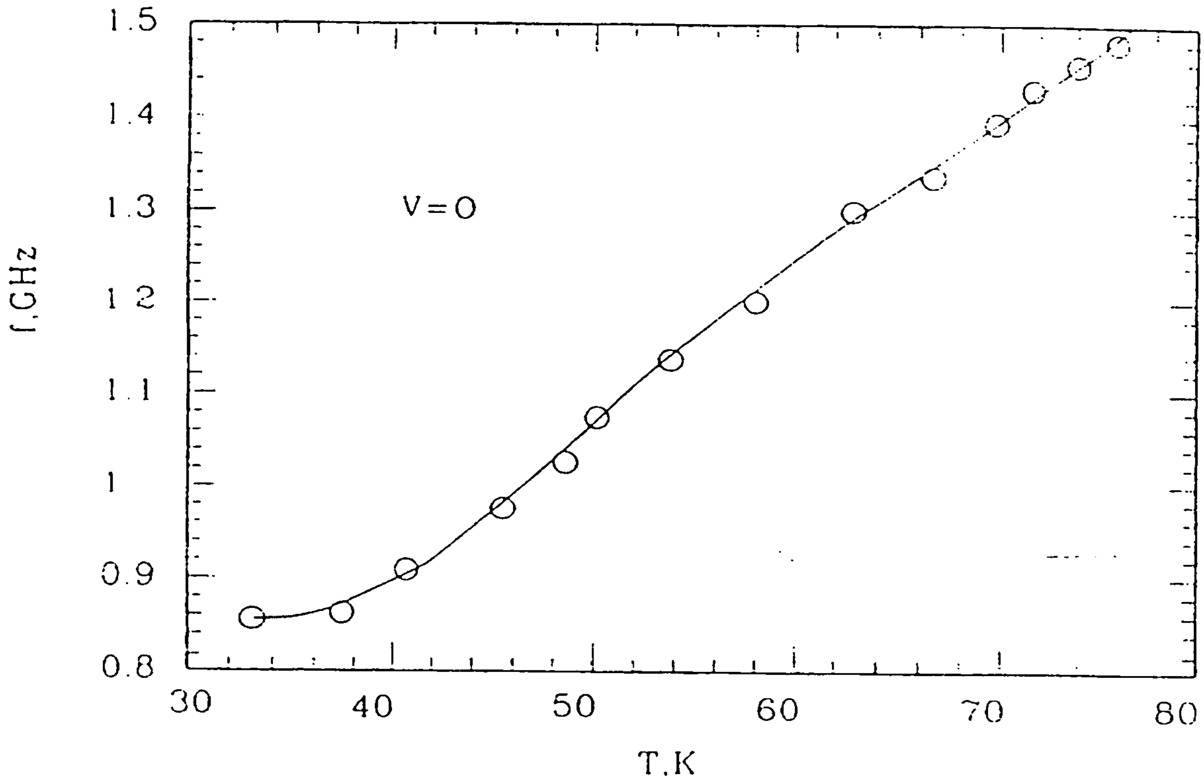

1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
f,GHz
V=0
30
40
50
60
70
80
T,K

FIG.6a

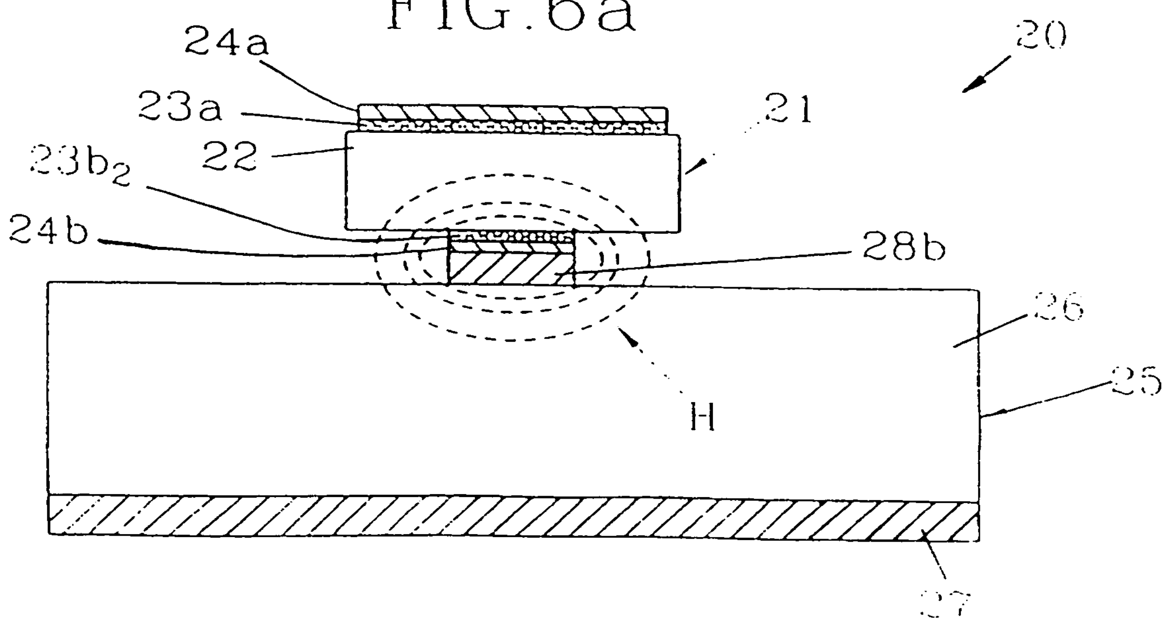

24a
23a
22
$23b_2$
24b
21
20
28b
26
25
H
27

FIG.6b

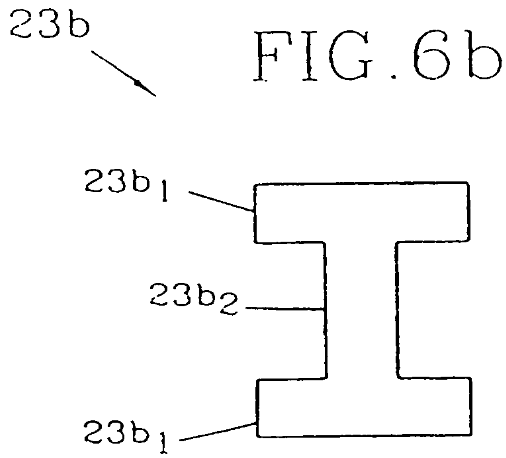


FIG.6c

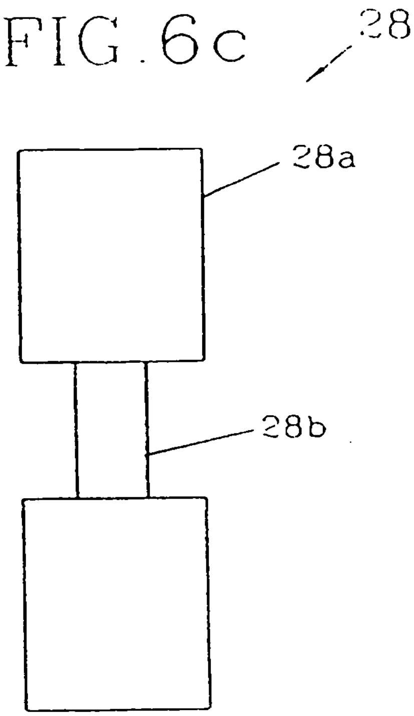


FIG.7

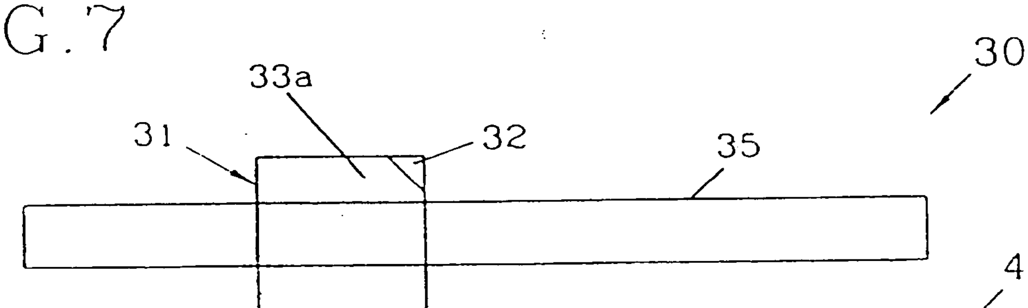


FIG.8

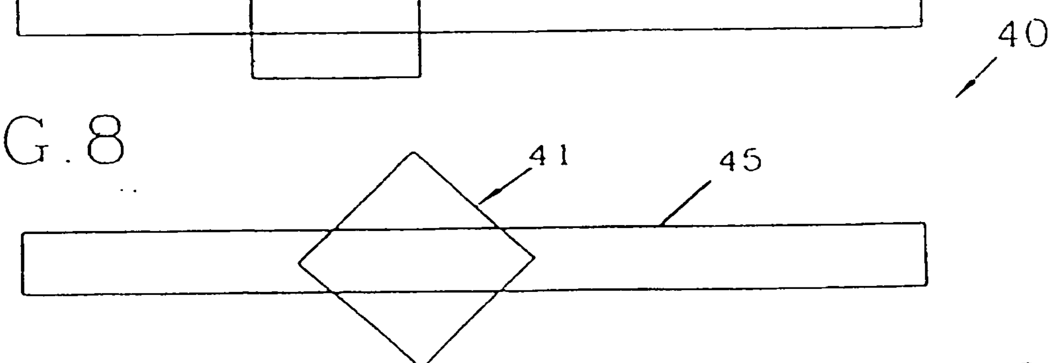
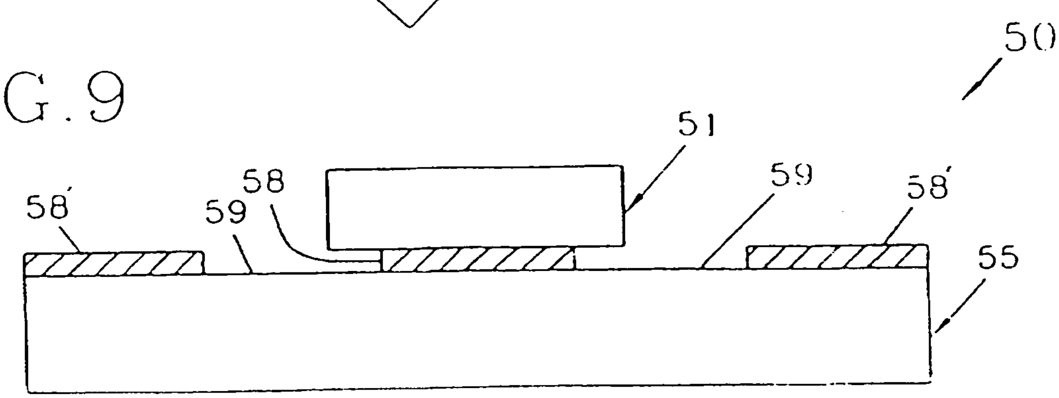


FIG.9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/01688

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01P 1/203

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4835498 A (ROUGER ET AL), 30 May 1989 (30.05.89), column 1, line 8 - line 17; column 2, line 60 - line 65; column 3, line 26 - line 30, figure 8, column 4, line 4 - line 14, --	1-30
A	WO 9300720 A1 (SUPERCONDUCTOR TECHNOLOGIES INC.), 7 January 1993 (07.01.93), page 5, line 1 - page 6, line 11 --	1-30
A	EP 0567407 A1 (SUMITOMO ELECTRIC INDUSTRIES, LTD), 27 October 1993 (27.10.93), abstract --	1-30

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 March 1997	02 -04- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/01688

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	US 5496796 A (S. DAS), 5 March 1996 (05.03.96), abstract	1-30

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INTERNATIONAL SEARCH REPORT
Information on patent family members

04/03/97

International application No.
PCT/SE 96/01688

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		FR 2616594 A,B	16/12/88
		JP 1005101 A	10/01/89
WO 9300720 A1	07/01/93	CA 2111679 A	07/01/93
		EP 0591402 A	13/04/94
		JP 6509684 T	27/10/94
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		US 5512539 A	30/04/96
US 5496796 A	05/03/96	NONE	